

CLAIMS

What is claimed is:

- 5 1. An implantable cardiac stimulation device that applies
defibrillating electrical energy to at least one atrium of a heart at a time
which avoids inducing ventricular fibrillation of the heart, the device
comprising:
- an atrial fibrillation detector that detects atrial fibrillation of
10 the heart;
 a pacing pulse generator that applies a pacing pulse to at
least one of the ventricles responsive to the atrial fibrillation
detector detecting atrial fibrillation of the heart;
 a timer that times a time period through an evoked response
15 and a T-wave caused by the pacing pulse, the time period
completing after the T-wave; and
 a defibrillation pulse generator that applies the defibrillating
electrical energy to the at least one atrium of the heart responsive
to the timer completing the timing of the time period.
- 20 2. The device of claim 1 wherein the timer commences timing of
the time period beginning with the application of the pacing pulse.
3. The device of claim 2 wherein the time period is between about
25 350 milliseconds and 450 milliseconds.
4. The device of claim 1 wherein the pacing pulse generator
applies the pacing pulse to the right ventricle of the heart.
- 30 5. The device of claim 1 wherein the pacing pulse generator
applies the pacing pulse to the left ventricle of the heart.

6. The device of claim 1 wherein the pacing pulse generator applies the pacing pulse to both the right ventricle and the left ventricle of the heart.

5 7. The device of claim 1 further comprising a cardiac interval timer that times cardiac intervals of the heart responsive to the atrial fibrillation detector detecting atrial fibrillation of the heart and wherein the pacing pulse generator applies the pacing pulse after the interval timer times a cardiac interval longer than a minimum cardiac interval.

10 8. The device of claim 1 further comprising an evoked response detector that detects the evoked response and wherein the defibrillation pulse generator inhibits the application of the defibrillating energy responsive to the evoked response detector failing to detect the evoked
15 response.

 9. The device of claim 1 further comprising an atrial pacing pulse generator that applies an atrial pacing pulse to at least one of the atria after the timer completes the timing of the time period and before the
20 defibrillation pulse generator applies the defibrillating electrical energy to the atria.

 10. The device of claim 1 further comprising an atrial sensing circuit that senses P-waves of the heart and wherein the defibrillation pulse generator applies the defibrillating electrical energy to the atria in
25 timed relation to a sensed P-wave.

 11. The device of claim 1 wherein the pacing pulse generator applies a plurality of pacing pulses to at least one of the ventricles
30 responsive to the atrial fibrillation detector detecting atrial fibrillation of the heart, and wherein the timer times the time period following a last one of

the plurality of pacing pulses through the evoked response and T-wave caused by the last one of the plurality of pacing pulses.

12. The device of claim 11 wherein the pacing pulse generator
5 applies the plurality of pacing pulses on demand and wherein the timer times the time period after the pacing pulse generator applies the plurality of pacing pulses during consecutive cardiac cycles.

13. The device of claim 11 wherein the timer commences timing of
10 the time period beginning with the application of the last one of the pacing pulses.

14. The device of claim 13 wherein the time period is between
15 about 350 milliseconds and 450 milliseconds.

15. The device of claim 11 wherein the pacing pulse generator
applies the pacing pulses to the right ventricle of the heart.

16. The device of claim 11 wherein the pacing pulse generator
20 applies the pacing pulses to the left ventricle of the heart.

17. The device of claim 11 wherein the pacing pulse generator
applies the pacing pulses to both the right ventricle and the left ventricle of
the heart.

18. The device of claim 11 further comprising an evoked response
25 detector that detects the evoked response and wherein the defibrillation pulse generator inhibits the application of the defibrillating energy responsive to the evoked response detector failing to detect the evoked
30 response.

19. The device of claim 11 further comprising an atrial pacing pulse generator that applies an atrial pacing pulse to at least one of the atria after the timer completes the timing of the time period and before the defibrillation pulse generator applies the defibrillating electrical energy to the atria.

20. The device of claim 11 further comprising an atrial sensing circuit that senses P-waves of the heart and wherein the defibrillation pulse generator applies the defibrillating electrical energy to the atria in timed relation to a sensed P-wave.

21. An implantable cardiac stimulation device for applying defibrillating electrical energy to at least one atrium of a heart at a time which avoids inducing ventricular fibrillation of the heart, the device comprising:

atrial fibrillation detecting means for detecting atrial fibrillation of the heart;
ventricular pacing pulse generating means for applying a pacing pulse to at least one of the ventricles responsive to the detection of atrial fibrillation;
timing means for timing a time period through an evoked response and T-wave caused by the ventricular pacing pulse; and
defibrillation pulse generating means for applying defibrillating electrical energy to the atria after the timing means times the time period.

22. The device of claim 21 wherein the timing means commences timing of the time period beginning with the application of the pacing pulse.

23. The device of claim 22 wherein the time period is between about 350 milliseconds and 450 milliseconds.

24. The device of claim 21 wherein the pacing pulse generating means applies the pacing pulse to the right ventricle of the heart.

5 25. The device of claim 21 wherein the pacing pulse generating means applies the pacing pulse to the left ventricle of the heart.

10 26. The device of claim 21 wherein the pacing pulse generating means applies the pacing pulse to both the right ventricle and the left ventricle of the heart.

15 27. The device of claim 21 further comprising cardiac interval timing means for timing cardiac intervals of the heart responsive to the atrial fibrillation detector means detecting atrial fibrillation of the heart and wherein the pacing pulse generating means applies the pacing pulse after the interval timing means times a cardiac interval longer than a minimum cardiac interval.

20 28. The device of claim 21 further comprising evoked response detecting means for detecting the evoked response and wherein the defibrillation pulse generating means withholds the application of the defibrillating energy responsive to the evoked response detecting means failing to detect the evoked response.

25 29. The device of claim 21 further comprising atrial pacing pulse generating means for applying an atrial pacing pulse to at least one of the atria after the timing means times the time period and before the defibrillation pulse generating means applies the defibrillating electrical energy to the atria.

30 30. The device of claim 21 further comprising atrial sensing means for sensing P-waves of the heart and wherein the defibrillation pulse

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generating means applies the defibrillating electrical energy to the atria in timed relation to a sensed P-wave.

31. The device of claim 21 wherein the ventricular pacing pulse
5 generating means applies a plurality of pacing pluses to at least one of the ventricles responsive to the detection of atrial fibrillation, and wherein the timing means times the time period following a last one of the plurality of pacing pulses through the evoked response and T-wave caused by the last one of the plurality of pacing pulses.

32. The device of claim 31 wherein the ventricular pacing pulse
10 generating means applies the plurality of pacing pulses on demand and wherein the timing means times the time period after the ventricular pacing pulse generating means applies the plurality of pacing pulses during consecutive cardiac cycles.

33. The device of claim 31 wherein the timing means commences
15 timing of the time period beginning with the application of the last one of the pacing pulses.

34. The device of claim 33 wherein the time period is between
20 about 350 milliseconds and 450 milliseconds.

35. The device of claim 31 wherein the pacing pulse generating
25 means applies the pacing pulses to the right ventricle of the heart.

36. The device of claim 31 wherein the pacing pulse generating
means applies the pacing pulses to the left ventricle of the heart.

37. The device of claim 31 wherein the pacing pulse generating
30 means applies the pacing pulses to both the right ventricle and the left ventricle of the heart.

38. The device of claim 31 further comprising evoked response
detecting means for detecting the evoked response and wherein the
defibrillation pulse generating means withholds the application of the
5 defibrillating energy responsive to the evoked response detecting means
failing to detect the evoked response.

39. The device of claim 31 further comprising atrial pacing pulse
generating means for applying an atrial pacing pulse to at least one of the
10 atrial after the timing means times the time period and before the
defibrillation pulse generating means applies the defibrillating electrical
energy to the atria.

40. The device of claim 31 further comprising atrial sensing means
15 for sensing P-waves of the heart and wherein the defibrillation pulse
generating means applies the defibrillating electrical energy to the atria in
timed relation to a sensed P-wave.

41. In an implantable cardiac stimulation device, a method of
20 applying defibrillating electrical energy to at least one atrium of a heart,
the method comprising:

stimulating at least one of the ventricles with a ventricular
pacing pulse to cause an evoked response and T-wave;
waiting until the T-wave ends; and
25 applying defibrillating electrical energy to the at least one
atrium after the T-wave ends.

42. The method of claim 41 wherein waiting comprises
commencing timing of a predetermined time period beginning with the
30 application of the pacing pulse.

43. The method of claim 42 wherein the time period is between about 350 milliseconds and 450 milliseconds.

44. The method of claim 41 wherein stimulating comprises
5 applying the pacing pulse to the right ventricle of the heart.

45. The device of claim 41 further comprising detecting the evoked response including the T-wave and wherein applying is performed after the detected T-wave ends.
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46. The method of claim 41 wherein stimulating comprises applying the pacing pulse to both the right ventricle and the left ventricle of the heart.

47. The method of claim 41 further comprising timing cardiac intervals of the heart responsive to detecting atrial fibrillation of the heart and wherein stimulating is performed after the timing of a cardiac interval longer than a minimum cardiac interval.
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48. The method of claim 41 further comprising detecting the evoked response and wherein applying is performed only when the evoked response is detected.
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49. The method of claim 41 further comprising pacing at least one of the atria after the timing of the time period and before the applying of the defibrillating electrical energy to the atria.
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50. The method of claim 41 further comprising sensing P-waves of the heart and wherein applying comprises applying the defibrillating electrical energy to the atria in timed relation to a sensed P-wave.
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51. The method of claim 41 wherein stimulating comprises
applying a plurality of pacing pulses to at least one of the ventricles
responsive to the detection of atrial fibrillation, and wherein timing
comprises timing the time period following a last one of the plurality of
5 pacing pulses through the evoked response and T-wave caused by the
last one of the plurality of pacing pulses.

52. The method of claim 51 wherein stimulating comprises
applying the plurality of pacing pluses on demand and wherein timing is
10 commenced after the plurality of pacing pulses are applied during
consecutive cardiac cycles.

53. The method of claim 51 wherein timing comprises
commencing the timing of the time period beginning with the application of
15 the last one of the pacing pulses.

54. The method of claim 53 wherein the time period is between
about 350 milliseconds and 450 milliseconds.

20 55. The method of claim 51 wherein stimulating comprises
applying the pacing pulses to the right ventricle of the heart.

56. The device of claim 51 wherein stimulating comprises applying
the pacing pulses to the left ventricle of the heart.

25 57. The method of claim 51 wherein stimulating comprises
applying the pacing pulses to both the right ventricle and the left ventricle
of the heart.

30 58. The method of claim 51 further comprising detecting the
evoked response and wherein applying is performed only when the
evoked response is detected.

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